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A nudge in the right direction: the role of food choice architecture in changing populations' diets

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Populations' diets typically fall short of recommendations. The implication of this on ill health and quality of life is well established, as are the subsequent health care costs. An area of growing interest within public health nutrition is food choice architecture; how a food choice is framed and its influence on subsequent food selection. In particular, there is an appeal to manipulating the choice architecture in order to nudge individuals' food choice. This review outlines the current understanding of food choice architecture, theoretical background to nudging and the evidence on the effectiveness of nudge strategies, as well as their design and implementation. Interventions emphasising the role of nudge strategies have investigated changes to the accessibility, availability and presentation of food and the use of prompts. Empirical studies have been conducted in laboratories, online and in real-world food settings, and with different populations. Evidence on the effectiveness of nudge strategies in shifting food choice is encouraging. Underpinning mechanisms, not yet fully explicated, are proposed to relate to salience, social norms and the principle of least effort. Emerging evidence points to areas for development including the effectiveness of choice architecture interventions with different and diverse populations, and the combined effect of multiple nudges. This, alongside further examination of theoretical mechanisms and guidance to engage and inspire across the breadth of food provision, is critical. In this way, the potential of choice architecture to effect meaningful change in populations' diets will be realised.

Food choice: Choice architecture: Nudge: Behavioural economics: Diet

Diets falling short

Populations' diets typically fall short of recommendations. Inadequate consumption of fruit, vegetables, legumes, wholegrains, nuts and seeds, in parallel with excessive consumption of red meat, processed meat and sugar-sweetened beverages, is evident globally[1]. In the UK, for example, only 8 % of 11–18-year-olds and 31 % of adults meet fruit and vegetable guidelines[2]; oily fish consumption stands at 56 g/week for adults[2] (below the 140 g/week recommendation[3]) and adults consume 19 g/d dietary fibre[2] (again, below the 30 g/d recommendation[4]). Children's intake of free sugars is excessive, beyond the 5 % recommendation[4], at 13·5 % (4–10-year-olds) and 14·1 % (11–18-year-olds) of dietary energy intake[2]. Further, saturated fat intake in adults (11·9 %[2]) exceeds the recommended maximum of 10 % dietary energy intake[5], as does salt (8·4 g/d[6] beyond the recommended maximum of 6 g/d[7]).

This mismatch between government guidelines and a population's actual diet remains a fundamental challenge, with substantial implications reflected in the

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mortality and morbidity tolls associated with diet-related ill health[1,8]. The impact of diet and dietary patterns on individuals' quality of life[9,10] is clear. Likewise, health care costs are substantial with poor diet-related ill health costs in the UK of the order of £5·8 billion (2006/7)[11], projected to grow to an estimated £9·7 billion by 2050 for overweight and obesity-related health costs[12]. Globally, the economic impact of obesity has been estimated to be of the order of US$2 trillion[13].

Worldwide obesity prevalence provides the impetus and urgency to act, with more than 650 million adults with obesity, alongside more than 120 million children and adolescents[14]. In England specifically, one in five 4–5-year-olds is overweight (including obese) rising to one in three 10–11-year-olds being the same[15]. Moreover, diet is a modifiable risk factor, also pertinent to health inequalities, with, for example, men and those with manual occupations less likely to adhere to UK dietary recommendations[16].

A need to improve diets nationally, regionally and globally has been highlighted[1]. In addressing populations' diets, much of the emphasis has been on guidance and education, with the principle that advice translates into positive action from citizens. However, behaviour change is notoriously difficult, with translation not always straightforward. The utility of food choice architecture (how a food choice is framed, and the consequences on subsequent food selections) in this endeavour shows promise, and nudging populations to change their diets has clear and distinct potential. Similarly, there is mounting evidence steering a move away from the conventional stance of food choice as a rational and deliberative act. Interest in opportunities to change diets that do not rely on rational decision-making and engagement of citizens is growing. To this end, the development of theory and evidence-based interventions to actively support citizen access to a sustainable and healthy diet is critical.

The present paper (1) overviews current understanding of food choice, choice architecture and nudge strategies; (2) outlines some of the research conducted so far with populations, and considers the effectiveness of nudge strategies in changing food choice; (3) considers the design and implementation of nudge strategies; and (4) looks forward to potential future developments in this area.

Understanding food choice

Central to addressing the mismatch between government recommendations and citizens' diets is a robust understanding of food choice, which determines food intake, with its short- and long-term health consequences[17]. Promotion and prediction of behaviour change is not obvious, and requires a comprehensive understanding of conditions preceding behaviour[18]. Likewise, it is important to note the reciprocal relationship between food choice and provision; food provision influences consumer behaviour and food choice, which itself influences new product development and food provision.

Food choice is complex, dynamic and multifaceted. It is constructed individually, according to interrelated concepts which are shifting and not static. Multiple factors interact to culminate in an individual's preferences and food choice parameters which then shape food choice. As well as physiological drivers, the relevance of social, cultural and psychological aspects to food choice has long been recognised[19]. An early taxonomy of the determinants of food consumption behaviour categorised person-related factors, as well as properties of the food itself, and those related to the environment[20]. Further, food choice reflects and propagates sociocultural aspects and is a means of representing identity. Prior experiences and associations with food coalesce to influence food choice, and in this way, an individual's food choice history[21] is personalised and dynamic.

Various theoretical models (each with their limitations) conceptualise and examine food choice. The food choice process model posits that, across a life course, individuals' experiences affect food choice and inform personal systems, which incorporate value negotiations and personalised strategies[22,23]. Value negotiations assess various aspects (e.g. sensory perceptions, health and nutrition beliefs and concerns, social relationships) in order to make a food choice, and individuals employ strategies which are honed to simplify the process and guide routine food choice[22,23].

Using a life-course perspective, food choice trajectories recognise that foods, individuals and environments are not static, and food choice may undergo minor transitions and major turning points[21,24]. These deviations are triggered by an individual's change in circumstances; the nature of which, together with the individual themselves, dictate whether a turning point or less severe transition prevails.

Numerous models, notably the theory of planned behaviour[25] and its predecessor, the theory of reasoned action[26], highlight the central role of intention in behaviour change. Research confirms the importance of intentions in predicting behaviour[27,28], and importantly evidence also indicates that the intention–behaviour gap is large[29], with individuals encountering difficulties in translating intentions. Moreover, automaticity and habits may be more relevant, with the intentional control of behaviour seemingly more limited than previously considered[27].

Past behaviour guides, and is an important predictor of, future behaviour[30,31], including within the context of food[32,33]. Habits strongly predict eating behaviour, and are more dependent on the environment, less under intentional control, and largely outside conscious awareness[34]. Indeed, the automaticity of food choice and the sheer influence of social and environmental cues are gaining authority; this relates to an automatic behaviour being without qualities such as intent, control, effort, awareness[35]. Carefully considered decisions are atypical for everyday food choice, instead these decisions are largely automatic and habitual, using heuristics (rules of thumb) to act efficiently, because they have been made in the same contexts many times before, and therefore practices are honed. To this end, people rely on behavioural cues from others, and are strongly influenced by social context and norms[36–38]. Modelling of food

intake can be powerful and robust[39], particularly when individuals perceive themselves similar to the model or desire to affiliate with them[40]. There is also clear evidence for social facilitation, with people selecting and eating more when with friends[41]. Similarly, an individual's food order can be influenced by the person ahead in line[42]. The potential of harnessing social context to improve dietary intake has been highlighted[36].

Temporal or time discounting[43] is relevant in considering food choice, and specifically the intention–behaviour gap. This relates to how value decreases with time, how reward now outweighs later greater benefit, and how individuals tend to have more self-control for future, compared to immediate, plans. Indications are that high time discounting is a risk factor for unhealthy diets, as well as overweight and obesity[43].

In everyday food decisions, there may be several alternatives to choose from, each with their own attributes. Drift-diffusion models[44,45] explain how individuals accumulate evidence for options until this exceeds a threshold. Likewise, choices are biased by where someone looks and if they look for longer at one alternative[45]. One strategy that individuals use is heuristics[46,47]; these limit cognitive load thereby conserving capacity for other tasks[48], and may relate to features such as the look, shape, logo, price.

Ultimately, when it comes to food choice, individuals are not rational and do not make carefully considered decisions informed by guidance and evidence. Instead, everyday food decisions are largely automatic, habitual and poorly regulated, guided by non-cognitive processing[48]; consistent with quick, instinctive and emotional (system 1) processes as opposed to deliberative, rational and slow (system 2)[49,50]. Selection is made in the most efficient manner, to minimise mental and physical effort. Therefore, food choice is susceptible to environmental nudge strategies, and this is the opportunity afforded by choice architecture, to propel better food choice.

Choice architecture and nudge theory

With origins in the discipline of behavioural economics, the concept of nudge has developed since the early 1970s, culminating in the term in the late 2000s[51]. Today, nudge theory has become an area of immense interest including within public health nutrition. Pivotal to nudge theory is the concept of choice architecture[51]. This relates to how a choice is presented and its influence on decision-making[51]. Food choice architecture specifically incorporates all aspects of how a food choice is framed, and the consequences on subsequent food selections made[52]. This relates to, for example, the layout and wording of menu options, order of food in a buffet line, presentation of meals in a canteen, verbal prompts such as 'Would you like a side with your order?', and in essence, every aspect counts and signifies.

The prevailing choice architecture (either by design or otherwise) encourages or discourages certain food choice behaviour. Therefore, there is an appeal to manipulating the choice architecture in order to nudge individuals in a particular direction, towards specific choices. The changes to the choice architecture, the nudge strategies (nudges), are small subtle changes to the social and physical environment.

Central to nudge theory is libertarian paternalism[53]; this approach preserves freedom of choice alongside authority to guide people in a particular direction, considered to be beneficial to their welfare, i.e. a positive change for individuals' and wider societal interests. Government interest in nudge theory and libertarian paternalism continues, particularly where it is considered an attractive alternative to the removal of choice from citizens or the imposition of legislation. This is relevant in public health policy and food choice which impact on a nation's health.

Nudge strategies

Nutrition interventions theoretically grounded in nudge theory emphasise the role of nudge strategies to shift food choice. Purposeful choice architecture exploits the premise that most food decisions are automatic, utilising heuristics and biases as shortcuts, and nudge strategies direct food choice towards preferable decisions, promoting or demoting selection of 'target' foods.

Nudging entails priming in order to influence individuals' behaviour through cues; typically, it is without individuals' awareness and inherently involves a sidestepping of an individual's reasoning capabilities[54]. Many nudge strategies correspond to minimising the effort required for (or resistance to) selecting the promoted option, i.e. making the target choice the easy choice. Nudge strategies, typically minor and unobtrusive, do not require high cognitive effort and aim to effect change by operating within individuals' automatic processes. This includes reducing physical effort, cognitive load and/or time.

The nudge strategies may relate to changes to the accessibility, availability and presentation of food options and the use of prompts. With a core principle of retaining the freedom to choose[51,53], no food options are eliminated, and likewise, significantly changing economic incentives are not allowed[51]. Thus, changing the price of a food option or removing it would not constitute a nudge strategy, whereas changing its location would. Fig. 1 provides examples of nudge strategies related to food.

Overview of nudge strategies

Many nudge strategies are placement manipulations, straightforward changes to the location of food options, e.g. closer to the consumer, near the till, at eye level. The order of food options can also be adjusted (e.g. first in buffet/canteen line, first option on a menu) as can the availability (e.g. number available of promoted items). Particular food options can also be highlighted or emphasised in contrast with competing options, e.g. boxing on a menu. Other nudge strategies include changes to the presentation or format of food (e.g. grab-and-go pots, plate size, tongs to serve) and the addition of

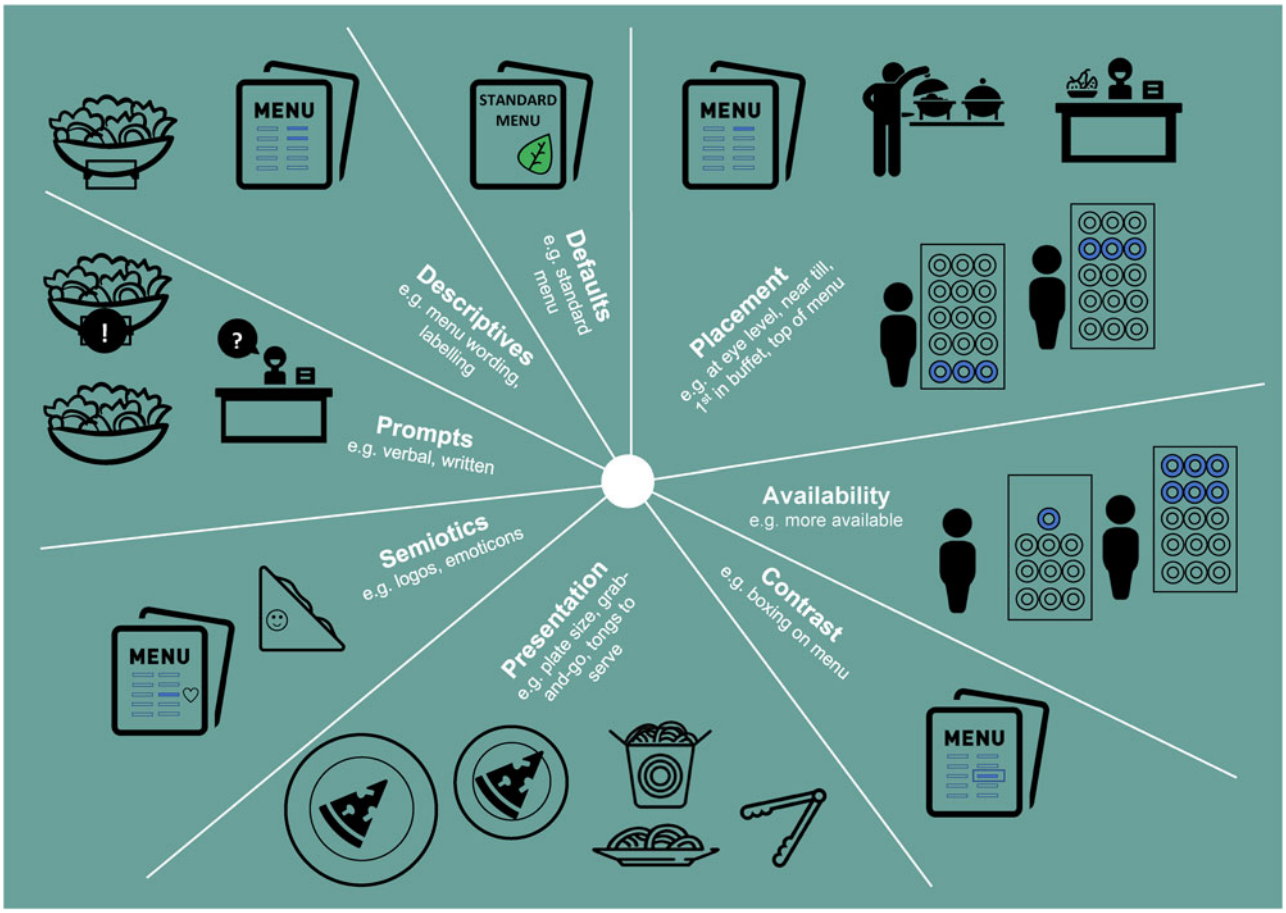

Fig. 1. (Colour online) Nudge strategies implemented in choice architecture interventions to change food choice: reducing effort and cognitive load, increasing salience and emphasising tastiness and social norms.

semiotics (icons or symbols, e.g. healthy heart labels, emoticon stickers). Nudge strategies can also incorporate descriptive names for target foods, e.g. slow-roasted sweet potato, or prompts, either written or verbal, e.g. 'Make a fresh choice', 'Would you like a side with that?' Finally, defaults (i.e. standard options that remain, unless an individual intervenes) can be utilised in nudge strategies, e.g. changing the standard meal option to a plant-based dish.

A scientific basis is essential to behaviour change interventions[55], and sound theory provides a solid foundation to inform our understanding of how and why nudge strategies may work, and propels future developments in the design of interventions and their effectiveness. Research evidence is outlined later, alongside a current understanding of mechanisms to explain the effects observed, which are not yet fully understood.

Empirical evidence and theory

Many placement nudge strategies work on the basis that options further away or less prominent will reduce their selection, and several studies have shown these to be effective in reducing snack selection[56–58]. Consumption of brownies and M&Ms was significantly higher when these were located 20 cm away from an individual compared to 70 cm[58]. A different study examining proximity demonstrated participants consuming more apple slices even when competing with a preferred higher energy food (buttered popcorn), positioned further away[59]. Further, a meta-analysis of nudge-based interventions focusing on fruit and vegetables revealed the largest effect size for placement nudge strategies[60]. The potential of repositioning foods to meaningful behaviour change as part of a wider strategy to improve food consumption[61] is evident.

Accessibility or convenience can also change food selection; increasing effort required by offering food that needs unwrapping can reduce intake and this has been shown with individual chocolates[62] and chocolate brownies[58]. Further, increasing physical effort (wrapped *v.* unwrapped brownie) and also positioning snacks further away can act independently and interactively to decrease snack consumption[58]. Other simple adjustments such as the specific location within a salad bar and also the provision of a pair of tongs *v.* a spoon can change (8–16 % difference) food choice[63]. Another study demonstrated how participants having to grab food with sugar tongs significantly reduced consumption of unhealthy (chocolate candies) and healthy (dried apricots) snacks[62].

Several mechanisms have been proposed to explain the effects observed. These include classical energy conservation and the principle of least effort[64,65] where shorter routes to goals are prioritised. Thus, required effort is reduced by bringing items closer or removing barriers (e.g. unwrapping food). Notably, previous work has shown distance affecting perceived effort and reducing selection[56]. A systematic review on positional changes highlighted evidence regarding the influence of proximity or order of food on food choice, with the strength of the effect apparently dependent on the kind of manipulation (order/distance) and its extent (e.g. how far away)[66].

Research has also shown how changing the component size of food is relevant, e.g. full-size brownies compared to halved[67], whole pretzels also halved[68]. Such effects have been attributed to a unit bias[68], a heuristic that choosing one item is appropriate. Presenting food in fun formats has also been investigated; one study conducted in primary schools found that consumption almost doubled when whole wheat bread was presented in fun shapes[69]. Interestingly, researchers found slight increases in children's perceived tastiness and enjoyment with the shape manipulations[69].

In examining how nudge strategies might be effective, it is important to consider the salience of an option, its prominence/contrast with its surroundings (e.g. its brightness, colour). Salience can have a strong effect on food choice, and salience bias (perceptual salience) is a cognitive bias where individuals facing multiple options focus attention on those that are particularly prominent. Manipulating salience and increasing the brightness of food images has been shown to promote selection, even when competing with unhealthy but tastier (participant perceived) alternatives[33]. Further, salience effects remained in conditions of additional cognitive load (when participants were given a cognitive task) or time pressure[33]. Salience may also underpin the effects observed in changing the order of food options (e.g. in a buffet line) and placement. However, some research has shown no effect of distance on perceived salience[56], and further work is needed to understand fully the implication of the distance moved and the potential relevance of the range of distances.

Placement nudge strategies have been explored on menus as well; placing items at the beginning or the end of options increased their selection by approximately 20 % from the middle[70]. Attractive descriptive names for food options have been reported to impact the likelihood of selection[71,72]. Other work has examined 'sweet spots' on menus, i.e. points where consumers first gaze or spend most time looking at. Although empirical evidence is inconclusive as to the merit of placing options at these points[73], a study with older adults in assisted living residences indicated that this did significantly affect selection[74]. Likewise boxing of food options was shown to increase the selection of healthier items[74]. Salience may be pertinent in the effects observed, as well as those when positioning food options at the top or bottom of a menu. The relevance of position within a menu has also been linked to primacy and recency effects[71,75], cognitive biases whereby items encountered at the start or end are recalled more clearly.

Increasing the availability (e.g. relative share/number available of promoted items) has been reported to improve selection[61]. As well as salience (increased with more items on show), another proposed mechanism relates to social norms, specifically descriptive norms, i.e. perceptions of the prevalence of a behaviour, communicated via the increased availability. Research has also examined the addition of semiotics, i.e. icons or symbols (e.g. heart logos[76,77], emoticons[52,78]) as a nudge strategy. These additions affect salience and promote selection through individuals' heuristic use, particularly where there are multiple options to choose from. Indeed, this points to the relevance of minimising effort expenditure, cognitively as well as physically. Interestingly, there may be a distinct advantage to subtle messaging, i.e. logo *v.* explicit message. One study revealed a heart logo commonly used to indicate a healthy food item was effective in increasing selection, whereas an explicit message ('A Healthy Choice') was ineffective[79]. This may be attributable to the different processing that each accesses, i.e. more automatic with the implicit and more deliberative rational with the explicit. Further, it is important to consider the potential of affect (experiencing an emotion or feeling) and, for example, an emotional response to icons or symbols used as nudge strategies, as well as any implicit approval conveyed, e.g. smiley face.

Default-based nudge strategies such as standard food options have been shown to increase their selection[80]. The relevant underpinning mechanisms relate to the principle of least effort, with individuals remaining with the default for convenience and minimising cognitive effort. Likewise, mechanisms may relate to norms communicated through the standard, i.e. defaults provide a strong indication of social norms, which act as a heuristic for an appropriate food choice. Another potential mechanism relates to status quo bias[81], with individuals tending to maintain the status quo as the disadvantages of leaving loom larger than the potential advantages. Providing information about eating norms can also be effective in changing individuals' food choices[37,82]. Consistent evidence attests to the effect on food choice, as well as food intake norms influencing the quantity of food consumed[37]. Further, the perceived norm originating from a socially proximal group has been shown to be relevant, with behaviour affected when the norm is from an 'in-group'[83].

Nudging and the place of taste

Overall, the mechanisms for the effects observed with nudging and choice architecture interventions are yet to be fully explicated. Nudge strategies influence food choice, however the place of taste for individuals must be respected. It is important to appreciate how extraordinarily important hedonic reward is in food decisions, and that highly palatable foods win. Therefore, in the simplest way, people's food choice parameters dominate, and within these, taste rules supreme and typically overrides other considerations.

It is proposed that for a nudge strategy to be effective and a consumer to choose an option, their perception of the tastiness of the food needs to be satisfied, prior to selection. In other words, a consumer may be diverted elsewhere, regardless of the nudge strategy. Indeed, this is supported by an early study which found that making desserts less accessible had an effect when implemented on low-energy desserts (e.g. fruit) but not high-energy desserts (e.g. cakes)[84]. Other work found that whilst it may be straightforward to induce increased consumption of palatable foods by social influence, this is not the case with unpalatable foods[85]. Health-focused labels may also deter selection given that consumers may implicitly subscribe to healthiness and tastiness being inversely related[86]. Further, it is interesting to consider how nudges can work with consumer perceptions in this regard. One review highlighted the potential approaches of enhancing multisensory desirability of salad greens[87], and another study demonstrated higher tastiness ratings for food arranged in an aesthetically pleasing manner[88]. Therefore, the key principles in establishing effective nudges may revolve around reducing effort and cognitive load, increasing salience and emphasising tastiness and social norms.

Nudging towards plant-based diets

As an environmentally sustainable food system becomes more compelling, there is increasing interest in how to nudge populations towards more sustainable diets. Such changes may be towards plant-based diets, including towards less familiar sources (e.g. algae, aquatic plants) as well as an emphasis shift from animal-based protein to plant-based protein, in line with some of the evidence relating to sustainable diets[89,90]. Likewise, there is compelling evidence regarding the health benefit of plant-based diets[91,92] and the replacement of animal with plant protein[93].

Manipulating food choice architecture to direct food decisions towards more plant-based sources holds promise, and empirical research in this arena has focused on, e.g. plant-based foods[52,72], vegetarian options[71], meat-free options[80]. Plant-based foods were the focus of a school-based intervention[52] which utilised multiple nudge strategies (including descriptive labels, grab-and-go pots, placement) to shift adolescents' food choice. Overall selection was significantly different during the intervention to the rest of the year and previous year, and children were 2·5 times as likely to select 'nudged' items during the intervention, compared to baseline[52].

Research conducted online has demonstrated how factors such as an option being the chef's menu recommendation and more appealing descriptions can increase the likelihood of a vegetarian dish choice[71]. Interestingly, effects were shown to differ depending upon past behaviour; infrequent vegetarian eaters were significantly more likely to choose a vegetarian dish (with a descriptive name, or boxed and captioned as 'chef's recommendation'), whereas those who ate vegetarian food more frequently had a reduced frequency of selection[71].

Research has also shown how utilising a default menu can increase sustainable food choices. The probability of choosing a meat-free option increased with the use of a default menu, and increased further with the use of 'appealing' meat-free options[80]. Work examining the language used for plant-based meals has also pointed to more effective wording to 'meat-free', as well as the advantage of experiential and indulgent language reflecting flavour, taste, enjoyment, e.g. 'melt in the mouth', 'mild and sweet'[72]. Other research has examined the value of descriptive language, with 25 % more people selecting vegetables labelled indulgently compared to neutral descriptions, and up to 41 % more people selecting these when compared to healthy labelling, e.g. 'rich buttery roasted sweet corn' (indulgent) *v.* 'corn' (neutral) *v.* 'reduced-sodium corn' (healthy)[94]. Other nudge strategies, such as 'climate-friendly choice' labels on meals have been effective in increasing selection, with indications that the longer the intervention, the greater the selection[95].

Design and implementation of nudge strategies

A developing understanding of nudge strategies proffers a compelling opportunity to specify and reshape existing food choice architecture. A methodology to do so is needed and indeed the lack of instruction on the implementation of nudges for practitioners has been highlighted[96]. This process revolves around two related components: the target food items (promoted/demoted); and the nudge strategies themselves, which should be considered together. Central to this is the scrutiny of the specific choice architecture. The importance of this is apparent in contrasting settings, e.g. a workplace cafeteria, a table service restaurant, pre-order menu system for hospital patients. Even within apparently similar settings, the unique framework of food choice must be analysed. The target food items are dictated to some extent by the desired shift, or specific criteria. Previous work, for example, has centred on fruit and vegetables[60], vegetarian food options[71], meat substitutes[97], whole wheat bread[69], leafy greens[87], plant-based foods[52].

Robust characterisation of the food choice architecture is accomplished through multiple means, including observation visits, mapping and photographing the food environment, interviews (e.g. key informant interviews with catering managers, focus group/intercept interviews with consumers), analysis of menu cycles/recipes and interrogation of food choice data. Integrated findings provide a comprehensive account of food choice within the specific setting, in order to then develop and refine candidate nudge strategies. Subsequent consultation with stakeholders provides feedback to distinguish those nudge strategies that are worthy of further refinement, from those impractical or redundant. This stage also fosters ownership of the changes and can support intervention fidelity, and feasibility of wider roll-out.

Choice architecture interventions to nudge populations

There is a growing body of literature on nutrition interventions underpinned by nudge theory. This work is

being conducted internationally, including in the UK and Europe, with a preponderance of the evidence from US studies. Research has been conducted in laboratories[59,98,99] as well as online[33,71,72]. Critically, there is also a growing body of work conducted in real-world food settings[100] such as schools[101,102], university cafeterias[103,104], workplace[105] and healthcare sites[106]. To date, populations have included children and adolescents[101,102,107,108], young adults at university[109], adults[110] and older adults[74]. Similar effects in adults and children have been reported[100] and a systematic review[108] examining children's dietary behaviour and nudge interventions found positive results in thirty-three of the forty studies. Interestingly, positive effects were less likely in preschool (younger) children and it was proposed that younger children might be less susceptible due to their greater reliance on their own internal regulation as opposed to external food choice architecture[108].

Frameworks and typologies

The importance of typologies and frameworks to propel further development in this area has been recognised, particularly with respect to supporting empirical research and impact on practice and policy. This is an active area and there are commonalities and distinctions between various contributions.

A framework of three degrees of nudges, based on the extent of the intrusion on a consumer's autonomy in decision-making, has been proposed[111]. First-degree nudges entail straightforward provision of information and are reliant on full autonomy for an informed rational decision; second-degree nudges lend themselves to behavioural or volitional limitations and bias the desired decision; and third-degree nudges involve greater behaviour manipulation and may include framing devices, salience and affect[111].

Likewise, 'pure' nudges operating within automatic responses can be distinguished from changes that potentially instigate more deliberative decisions[111], e.g. providing information. This distinction is not universally accepted and indeed some proponents incorporate information giving within nudges. It is plausible that there is a continuum with, for example, energy labelling, front-of-pack nutrient profiling and emoticons all at different points, such that an emoticon accesses automatic decision-making whereas energy labelling requires more deliberative processes. This argument is supported by findings from a meta-analysis[112] that interpretive menu labels (e.g. traffic light, healthy heart symbols) but not informative menu labels (i.e. energy labelling) affected selection and consumption.

MINDSPACE (messenger, incentives, norms, defaults, salience, priming, affect, commitments, ego)[113] was one of the earliest frameworks and sought to collate the most effective behavioural influences. The UK's Behavioural Insights Team developed the EAST framework[114], advocating the principles of easy, attractive, social and timely for a behaviour to be encouraged. Another key development was a provisional typology of choice architecture interventions, based on adjusting placement, properties and both[115]. This was later developed to TIPPME (typology of interventions in proximal physical micro-environments), with fewer intervention types and a recognition that it is linked to a more general concept of physical environment, and that whilst interventions within the typology might map onto the concept of nudging to some extent, this is not a required feature[116].

Overlaps, where nudge strategies have features straddling more than one category, are evident, and this was acknowledged for an affect/behaviour/cognition categorisation[100] devised in a meta-analysis restricted to real-world empirical evidence[100]. Cognitively oriented interventions aimed to adjust what consumers know, e.g. nutrition labelling; affectively oriented interventions aimed to adjust how consumers feel without adjusting knowledge, e.g. verbal prompts, attractive descriptions; and behaviourally oriented interventions aimed to directly adjust behaviour without adjusting consumer knowledge or feelings, e.g. first in buffet, pre-sliced fruit[100].

Effectiveness of choice architecture interventions

Numerous systematic reviews[66,96,101,102,105–108,117,118] and several meta-analyses[60,61,100,110,112] have examined the evidence on choice architecture interventions for changing food choice. There are strong indications that nudge strategies hold promise[60,66,101,108,110,119], and there is a growing consensus on their merits and potential to shift populations' diets. However, inconsistent findings are evident[107,118] and the quality of studies has been emphasised as critical in making further progress in the field.

Research to date shows that the effectiveness of nudge strategies ranges from weak to moderate, with variation across nudge strategies, and a growing interest in combined *v.* individual nudges. Nudge strategies are also considered to be more effective in time-pressured settings and with lots of choices, i.e. where food choice is particularly susceptible to being automatic. Evidence is also emerging that the most effective nudge strategies may be those that are behaviourally oriented[100] (i.e. look to change behaviour most directly).

A meta-analysis[110] of forty-two studies restricted to adults found that nudge strategies resulted in a 15·3 % increase in healthier consumption (measured by the frequency of healthy choices or overall energy intake). The authors highlighted the potential of nudging as a strategy to support healthy eating and recommended further work in different settings and countries[110]. Another meta-analysis[112] of seventeen studies examining menu labelling and the provision of energy information, as well as more interpretive information (e.g. traffic light symbols, heart symbol), found that energy alone did not have an effect, whilst contextual or interpretive detail did. These supported consumers' selection and consumption of less energy, i.e. −280·3 kJ (−67 kcal) and −338·9 kJ (−81 kcal), respectively[112]. A Cochrane review[61] reported the effects of changing the proximity or order of foods, or the number (or relative proportion) of options available. Authors concluded that repositioning

or changing the availability of options could contribute to behaviour change; however, they pointed to the limited evidence base, and limited confidence in estimated effects[61]. The first meta-analysis to indicate promising medium effect sizes utilised fourteen well-documented studies of interventions to shift fruit and vegetable selection; placement and combined nudges provided significant effects on food choice (effect sizes, $d = 0{\cdot}39$ and $d = 0{\cdot}28$, respectively)[60]. The need for greater reflection on study design and reporting statistical techniques was also highlighted[60]. Finally, one comprehensive meta-analysis[100] examined ninety-six studies of choice architecture interventions, restricted to real-world settings. An average effect size of 0·23 was reported; although considered small, researchers translated this to an equivalent 518·8 kJ/d (124 kcal/d), approximately 7·2 %) reduction in energy intake[100]. Effect size increases were also reported as the focus of the nudge strategy shifted from cognition to affect to behaviour, with the largest effect size being the equivalent of −874·5 kJ/d (−209 kcal/d)[100]. When considered on a population level, this reveals the potential impact of nudge strategies and choice architecture interventions in addressing shortfalls in populations' food choice behaviour.

In the considered meta-analyses, different types of nudge strategies targeting different foods were considered, and each focused on food choice and/or consumption. In examining studies, the distinction between food choice and consumption should be acknowledged; however, choice is an overriding influence on consumption and evidence suggests that measuring food choice, as opposed to the more challenging food consumption, may be used to test the impact of interventions[100].

Policy and practice

Traditionally, public health interventions have centred on education, regulation and taxation. Indeed, much of the emphasis has been on nutrition guidance and information, on the basis that advice would translate into action. Historically borrowed from doctor–patient models, this is less effective in behaviour change for prevention and has been highlighted as a common mistake[18], where advice and guidance may be insufficient to shift habitual behaviour. Interventions based on nutrition education or changing attitudes rely on better food choice on the basis of rational and deliberative decision-making. This overlooks the premise that everyday food choice is automatic and habitual. Indeed, heuristics and food choice parameters provide some explanation as to why such interventions may be limited.

Automaticity of food choice processes is formidable. For success, we need to develop supportive and nurturing food choice architecture that safeguards better choices, in contrast to existing choice architecture which often challenges and, in some cases, undermines favourable diets. Evidence from systematic reviews is increasingly pointing to the utility of choice architecture interventions in this endeavour. Implementing nudge theory to bring about behaviour change is seemingly an approach more aligned to changing everyday food choice. Effecting change by operating within individuals' automatic responses, nudge strategies do not rely on high cognitive effort and work on the principle of reducing the effort required to get to the designated choice. To that end, choice architecture interventions present an effective solution to adjusting some population-level behaviours for improvements in public health[18].

The promise of choice architecture can be instigated at multiple points across the breadth of food provision from schools and workplaces, fast food outlets and restaurants, to markets and supermarket retailers. Leadership and guidance are needed for establishments that are interested to manipulate food choice architecture supportive of positive change. Specifically, practical tools and support to select appropriate nudges should be developed in order to engage and inspire stakeholders to take action. The role of government and policy is paramount, e.g. restrictions regarding the location of high in fat, sugar or salt products in retail settings included in the UK government's strategy for tackling obesity[120].

The potential of nudge strategies

Evidence to date points to the substantial and valuable role of nudge strategies and choice architecture interventions in addressing diet shortfalls. This can be attributed to four key reasons. First, nudge strategies can be effective in shifting food choice and therefore it is plausible to orchestrate a difference in diet. The second key reason is the typical low cost associated with implementation and maintenance. This is pertinent when considering under-resourced sectors and the possibility of scaling up interventions. Third, because of its nature, nudging can affect whole populations, and lends itself to propagating small changes, which on a population basis is considerable. Indeed, nudging resonates well with public health policy emphasising minor changes individually, culminating in substantial improvements at a population level. Further, it is compelling that nudging is not reliant on education or income and provides the potential to tackle health inequalities. The fourth reason is that nudge strategies do not interfere with food provision, with no changes or restrictions to *what* is available to choose. This can promote stakeholder engagement, particularly when considering the catering and retail sectors involved and their business models.

Research priorities and future developments

The evidence surrounding the effectiveness of nudge strategies in shifting food choice is growing, as is the literature base in support of the potential for such strategies to change populations' diets. Given the potential, there is a need to invest in further research. Due to the likely differential with respect to laboratory settings and research conducted in real-world settings, there is a need for further real-world research[61,118,119]. There is also a need for a greater understanding of the extent to which people

mind being nudged or otherwise. This is relevant as acceptability influences implementation at government level. Evidence of public approval of nudging for health reasons[121] and specifically to promote healthy eating[122,123] may propel a move towards greater transparency. This would address some of the ethical dimensions relating to nudges, previously outlined[54]. Alongside this, further evidence is needed on whether knowing you are being nudged matters in terms of the effect of the nudge; indications to date are that consumers' awareness does not necessarily change the effect of nudges[124–126].

Another area for future development relates to unintended consequences, where individuals may compensate for nudged food choices with less preferable additions, e.g. side dishes, drinks, thereby undermining positive outcomes. Some evidence on compensatory behaviour has been reported[127,128] and it is important to examine this further, in order to appreciate how to mitigate against it. Further, opportunities to test outcomes for choice architecture interventions against established health promotion interventions would be valuable in ascertaining advantage, and these have been called for[119]. This will inform intervention and policy design to support populations.

Among all potential areas for development and based on emerging evidence, two key areas however are worthy of special consideration. First, the effectiveness of choice architecture interventions with different populations is critical, and the need for further work in this area has been recognised[110,117,119]. Similarly, there is a need to better characterise populations and further research with diverse populations and also emerging market economies is warranted. The second area relates to a lack of research examining the combined effect of multiple nudges, particularly as effects may be individualised and meaningful impact may require multiple nudges[108]. These together will contribute to a better understanding of the dynamics between choice architecture and food choice.

Conclusions

There is an obvious imperative to address populations' diets. It is essential that policy and practice prioritising health and wellbeing embrace the complexity of food choice and look beyond traditional routes. Evidence to date on nudge strategies to change food choice is growing and shows great promise. It is clear that choice architecture has a distinct and vital role to play in improving populations' diets. Investment in further research to establish and exploit the opportunities afforded by food choice architecture is critical. As opposed to the present-day position which can challenge and undermine favourable diets, there is a need to drive supportive choice architecture as the norm. Guidance to engage and inspire decision makers across the breadth of food provision will propel this positive action. Ultimately, choice architecture and nudge strategies offer the potential to realise change in populations' diets.

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